CHAPTER II - STREETS

210 STREET DESIGN

210.1 SUBGRADE EVALUATION

Soil testing to obtain the strength of the soil is required for all roads and streets in order to analyze and design the structural section. Soil tests are needed on undisturbed samples of the subgrade materials that are expected to be within three (3) feet of the planned subgrade elevation. Samples are needed for each five hundred (500) feet of roadway and for each visually observed soil type. Soil tests are required from a minimum of three (3) locations.

The selected design structural strength of the soil needs to be consistent with the subgrade compaction requirements. The strength and compaction moisture content, at optimum to slightly over optimum, needs to be specified. The soils report shall address subgrade drainage and ground water considerations for year round conditions. Recommendations for both summer and winter construction shall be included. The required density of treated and untreated subgrade materials shall not be less than 95 percent maximum density as determined by AASHTO T-99.

210.2 STRUCTURAL SECTION

The following materials may be used for street structural section construction. The structural section type shall not change between major intersections; only one type of section shall be used. At transitions between asphaltic and portland cement concrete structural sections, appropriate portland cement concrete impact slabs shall be designed and installed. Special pavement types and/or conditions to be approved by the city engineer.

1. Full depth asphaltic concrete.

2. Asphaltic concrete with crushed rock base or treated bases.

3. Portland cement concrete with cushion course of crushed rock or on a base of crushed rock or treated base.

210.2.1 AGGREGATE BASE

All aggregate shall meet OSHD specifications for base rock.

The minimum aggregate section, unless otherwise approved by the City Engineer, shall be an 8-inch base course of 1 1/2 - 0 inch with a 2-inch leveling course of 3/4 - 0 inch. This equals a total minimum section of 10 inches of aggregate.

During compaction, materials shall be maintained within 2 percent of the optimum moisture content. The contractor shall begin compaction of each layer immediately after the material is spread, and continue until a density of not less than 95 percent of the maximum density has been achieved. Maximum density will be determined by AASHTO T-180, or OSHD TM-106.

210.2.2 ASPHALT PAVEMENT DESIGN

The base course of asphalt concrete (AC) streets shall be a minimum of 2 inches of OSHD class "B" and the wearing course shall be 1-1/2 inches of OSHD class "C" for a total minimum thickness of 3-1/2 inches placed in two (2) lifts. For asphalt thickness greater than 3-1/2 inches, no single lift shall be applied in excess of 2-1/2 inches.

The specific grade of asphalt cement shall be PBA 5 (Performance Based Asphalt) or equal as approved by the City Engineer.

The compaction shall be at least 91 percent based on a Rice theoretical maximum density, as determined in conformance with AASHTO T 209, as modified by OSHD. In addition, for each mix used, a 50 blow Marshall (AASHTO T 245) shall be performed and all related test data shall be provided to the City Engineer. The minimum stability shall be 1800 pounds, the flow shall be between 8.0 and 16.0 hundredths of an inch, and the voids shall be between 3.0 and 5.0 percent. The Marshall requirement may be waived by the City Engineer on a case-by-case evaluation. Asphaltic pavement lift (if no single lift averages less than 89%, then all lifts need to be averaged together) with an average in-place relative density between 90% to 91% shall require a three year Maintenance Warranty (100% of the cost of removing and replacing the asphalt); and if the average in-place relative density falls between 89% and 90% inclusive, a five year Maintenance Warranty (100% of the cost of removing and replacing the asphalt) shall be required. If the average density is less than 89% then the asphalt shall be deemed unsuitable, and will be rejected. The Engineer of Record shall than submit a plan to remove and replace the asphalt which was rejected to the City Engineer for approval. Asphalt shall be placed on a dry prepared surface when the surface temperature is not less than 50 degrees F for the top lift and 45 degrees F for the base lift.

Asphalt pavement shall be designed using any nationally recognized procedure, both the OSHD and the Asphalt Institute methods are discussed below.

Oregon State Highway Division Method

Test the soil to determine the R-value by AASHTO 190. Source: Reference 1. Design and testing guidelines are available from the state offices in Salem or the Washington County Department of Land Use and Transportation's Road Engineering staff.

Determine the 18 kip Equivalent Axle Load (EAL) constant. Use a Traffic Analysis Worksheet (See Figure 2-1) to calculate 18 kip EAL and the Traffic Coefficient. The 2-way traffic should be based on vehicle classification counts and functional classification of the street. The expansion factor for a twenty (20) year period and the daily traffic for each project shall be determined by a traffic study or provided by the City.

Calculate the total structural thickness for the roadway section in terms of the crushed aggregate base. This is the Crushed Base Equivalent in inches, (CBE).

- CBE = 0.03546 (TC) (100-R)

Choose the structural section for the street using Table II a (Chapter 2).

Asphalt Institute Method

Design of asphalt concrete pavement structures by this method shall conform to the guidelines of The Asphalt Institute Publication, Thickness Design - Asphalt Pavements for Highways and Streets, Manual Series No. I.

- Source: Reference 2, or
- AASHTO T-193 (CBR Method), or
- AASHTO T-190 (R-Value Method), or
- Source: Reference 1.

If the CBR value of the subgrade exceeds twenty (20) or the R value of the subgrade exceeds sixty (60) then CBR and R-value methods shall not be used.

210.2.3 DESIGN EXAMPLE

AC STRUCTURAL SECTIONS EXAMPLE (OSHD METHOD)

- FIND: STRUCTURAL SECTION (Asphaltic Concrete)

- Given: 24-HOUR TRAFFIC MIX (90-2 axle trucks, 45-3 axle trucks, 5-4 axle trucks, 90-5 axle trucks, 0-6 axle trucks, 25-Tri-Met buses)

- R = 6 (OSHD Method)

- STEP I. Complete the traffic analysis worksheet, Figure 2-1, as shown in Figure 2-2.

- STEP II. TC = 9.2 (from Step I)

- STEP III. Go to Table II, with R = 6, and TC = 9.2, find CBE = 31.8"

- STEP IV. Using CBE factors from Table II, go to CBE factors Table II and find that:

  - Alternative I

    4-inch AC X 2 = 8.0-inch CBE

    2-3/4 inch X 0.8 = 1.6-inch CBE

    13-inch CTB X 1.8 = 23.4-inch CBE
    33.0-inch CBE

  or we find an alternate structural section could be:

  - Alternate II

    8-inch AC X 2 = 16.0-inch CBE

    2-3/4-inch-0 x 0.8 = 1.6-inch CBE

    18-inch 2-0 inch x 0.8 = 14.4-inch CBE
    32.0-inch CBE

FIGURE 2-1 TRAFFIC ANALYSIS WORK SHEET

PRESENT ADT_____ STREET _____

PRESENT NUMBER OF: FROM _____
2 Axle trucks_____
3 Axle trucks_____ TO _____
4 Axle trucks_____ D = BxC
E = $\frac{B+D}{2}$

TRI-MET BUSES_____

5 Axle trucks_____ F = One-Way Annual

6 Axle trucks_____ G = ExF

$$TC = 9\ \frac{\text{18 Kip EAL}}{\text{20 Year 18 Kip EAL}}\ \frac{\text{20 Year 18 Kip EAL}}{1{,}000{,}000}\ 0.119$$

A	B	C	D	E	F	G
2		1.48			36.5	
3		1.48			19.5	
4		1.48			57.0	
5		1.48			296.0	
6		1.48			325.0	
TMB*		1.48			540.0	

TOTAL - AVG. ANNUAL 18 kip EAL = ____

18 Kip EAL/day = ____

20 Year 18 Kip EAL = ____

Traffic Coefficient, TC = ____

* TMB abbreviates Tri-Met Buses

FIGURE 2-2 - TRAFFIC ANALYSIS WORK SHEET (EXAMPLE)

PRESENT ADT 3800

STREET A Street

PRESENT NUMBER OF:
2 Axle trucks 90
3 Axle trucks 45
4 Axle trucks 5
Tri-Met Buses 25
5 Axle Trucks 90
6 Axle trucks 0
18 Kip EAL
TC = 9 20 Year 18 Kip EAL / 1,000,000 = 0.119

FROM X Road
TO Y Road
D = BxC
E = (B+D)/2
F = One-Way Annual
G = ExF

A	B	C	D	E	F	G
2	90	1.48	133.2	111.6	36.5	4073.4
3	45	1.48	66.6	58.8	19.5	6688.1
4	5	1.48	7.4	6.2	57.0	973.4
5	90	1.48	133.2	111.6	296.0	33,033.6
6	0	1.48	0	0	325.0	0
TMB*	25	1.48	37.0	31.0	540.0	16,740.0
						61,488.5

TOTAL - AVG. ANNUAL 18 kip EAL	=	61,488.5
18 Kip EAL/day	=	168.5
20 Year 18 Kip EAL	=	1,229,770.0
Traffic Coefficient, TC	=	9.2

*TMB Abbreviates Tri-Met Buses

TABLE IIa - CRUSHED BASE EQUIVALENT ALL ROADS

Minimum Traffic Coefficient	Minimum "CBE" Requirement						
	R=4	R=8	R=12	R=18	R=22	R=26	R=30
12.0-13.0	42.5"	41.0"	39.0"	36.5"	34.5"	33.0"	31.0"
11.0-12.0	39.0"	37.5"	36.0"	33.5"	32.0"	30.0"	28.5"
10.0-11.0	36.0"	34.5"	33.0"	30.5"	29.0"	27.5"	26.0"
9.0-10.0	32.5"	31.0"	29.5"	27.5"	26.5"	25.0"	24.0"
8.0-9.0	29.0"	27.5"	26.5"	24.5"	23.5"	22.5"	21.0"
7.0-8.0	25.5"	24.5"	23.5"	22.0"	21.0"	20.0"	18.5"
6.0-7.0	22.0"	21.0"	20.0"	19.0"	18.0"	17.0"	16.0"
4.8-6.0	18.5"	17.5"	17.0"	15.5"	15.0"	14.0"	13.5"
Below 4.8	16.5"	15.5"	15.0"	14.0"	13.5"	12.5"	12.0"

CBE FACTORS

1.0"	Asphaltic Concrete Wearing Surface or Base	=	2.0" Aggregate Base
1.0"	Emulsion Treated Wearing Surface or Base	=	2.0" Aggregate Base
1.0"	Cement Treated Base *	=	1.8" Aggregate Base
1.0"	Plant Mix Bituminous Base	=	1.8" Aggregate Base
1.0"	Oil Mat	=	1.8" Aggregate Base
1.0"	Cement Treated Existing Roadway Material	=	1.5" Aggregate Base
1.0"	Lime or Cement Treated Subgrade	=	1.0" Aggregate Base
1.0"	Aggregate Subbase	=	0.8" Aggregate Base

Above Factors apply to materials that comply with Washington County Standard Specifications and Special Provisions.

Use fabric mat where moisture is present in the subgrade, or use fabric mat plus excavate an additional 12 inches and replace with rock for unusually wet subgrade conditions.

SOURCE: REFERENCE 3.

* Lime treated base is to be considered to have the same aggregate base equivalent as cement treated base (1.8 inch).

210.2.4 PORTLAND CEMENT CONCRETE PAVEMENT

The design of portland cement concrete streets shall be governed by the guidelines and requirements of the Portland Cement Association (PCA) design procedures found in the below listed publications:

Concrete Streets: Typical Pavement Sections and Jointing Details
(1S211.01P) Source: Reference 4.

Thickness Design for Concrete Highway and Street Pavements
(EB109.01P) Source: Reference 5.

Joint Design for Concrete Highway and Street Pavements
(1S059.03P) Source: Reference 6.

The subgrade shall be tested to determine the Modulus of Subgrade Reaction, k, in order to design the street structure. A correlation of CBR to k may be made using Figure 2, Thickness Designs for Concrete Highway and Street Pavements. In addition, the City will require that the following be incorporated into the design and construction specifications:

A. Use a minimum twenty (20) year design period.

B. Minimum thickness of portland cement concrete shall be five (5) inches.

C. The minimum concrete specifications shall be 5000 psi (compressive) and 650 psi (flexural) in 28 days. The minimum cement content will be 660 pounds per yard, with a maximum water / cement ratio of 0.48. The slump shall range from 3-inch to 4-1/2-inch. The entrained air shall be from 4.0 to 6.0 percent.

D. A design joint plan shall be prepared and incorporated into the street construction plans. Longitudinal and transverse joint locations shall be clearly delineated. Transverse joints shall be skewed forward two (2) feet per lane with right and left curb street stationing noted for each end. Joint spacing (in feet) should not exceed 1.5 to 1.75 times the slab thickness (in inches). For example, an 8-inch thick slab would have a maximum joint spacing of 12 to 14 feet. The maximum length to width ratio shall be 1.25 : 1.0 for any panel unless there are other constraints that the City will examine on a case by case basis.

   Longitudinal joints shall be sawed at the same time or immediately following the transverse joints. Joints shall be sawed 0.25 inches in width and to a depth of at least one third the slab thickness. Sawing shall occur as early as possible, especially when large changes in temperatures are expected. At no time shall construction equipment or traffic be allowed on the new pavement until laboratory tests indicate at least 95 percent design strength has been attained, a minimum of seven days have passed since placement, or both the City Engineer and the design engineer agree that the street is ready for traffic and construction loads.

All joints shall be sealed. The concrete surfaces to which joint sealant will be applied must be clean and dry. To some degree, the technique or combination of techniques selected to accomplish this will depend on the conditions encountered in the field. Saw cutting (old joints), high pressure water jetting, sand blasting, wire brushing, and blowing out the joint with compressed air are methods that can be used. Air compressors used for this purpose must be equipped with traps capable of removing moisture and oil from the air. All residues must be removed from the joint that might prevent bonding of the joint sealant material. A 3/8-inch diameter, closed-cell, expanded polyethylene foam backer rod shall be placed in the joints according to the joint sealant manufacturer's recommendations. The joints shall be sealed with a hot rubber asphalt sealant (ASTM D3405 spec.) or Dow Corning 888 silicone sealant (or equivalent as determined by ASTM D1475, ASTM D3583, ASTM C719, and ASTM D793 spec.) and placed as per the manufacturer's specifications. The sealant type to be used shall receive approval from the City Engineer and be noted on the design joint plan. The surface of the sealant should be 1/4-inch beneath the surface of the pavement. All excess materials shall be removed from the surface.

E. All field testing shall follow ACI and OSHD procedures.

F. All other design criteria shall follow ACI and the 1990 APWA specifications.

210.3 HORIZONTAL ALIGNMENT

Alignments shall meet the following requirements:

- Center line alignment of improvements should be parallel to the center line of the right-of-way.

- Center line of a proposed street extension shall be aligned with the existing street center line.

- Horizontal curves in alignments shall meet the minimum radius requirements as shown in Table II·b.

Reversing horizontal curves shall be separated by no less than 50 feet of tangent. On arterials, the separation shall be no less than 100 feet.

TABLE II·b - DESIGN SPEED / CENTER LINE RADIUS – MINIMUMS

DESIGN SPEED (MPH)	FRICTION FACTOR (F)	SLOPE / R MINIMUM					
		(e) - 4%	(e) - 2.5%	(e) 0%	(e) 2.5%	(e) 4%	(e) 6%
Arterial and Collector Streets							
25	0.165	335’	300’	255’	220’	205’	185’
30	0.160	500’	445’	375’	325’	300’	275’
35	0.155	710’	630’	530’	455’	420’	380’
40	0.150	970’	855’	710’	610’	560’	510’
45	0.145	1285’	1125’	930’	795’	730’	660’
50	0.140	1665’	1450’	1190’	1010’	925’	835’
55	0.130	2240’	1920’	1550’	1300’	1190’	1060’
60	0.120	3000’	2525’	2000’	1655’	1500’	1335’
Neighborhood Routes and Local Streets							
25	0.252	195’	185’	165’	150’	145’	135’
30	0.221	330’	305’	270’	245’	230’	215’
35	0.197	520’	475’	415’	370’	345’	320’

NOTES:

For Table II·b - off right-of-way runoff shall be controlled to prevent concentrated cross flow in super-elevated sections. The above tables are to be used unless otherwise directed by the City Engineer or designee.

Super elevations will be required as directed by the City Engineer or designee. Where super elevation is used, street curves should be designed for a maximum super elevation rate of 0.04. If terrain dictates sharp curvature, a maximum super elevation of 0.06 is justified if the curve is long enough to provide an adequate super elevation transition.

On local streets, requests for design speeds less than 25 miles per hour shall be based on topography, right of way, or geographic conditions which impose an economic hardship on the applicant. Requests must show that a reduction in center line radius will not compromise safety. There will be posting requirements associated with designs below 25 miles per hour.

SOURCE: REFERENCE 7.

210.4 VERTICAL ALIGNMENT

Alignments shall meet the following requirements:

- Minimum tangent street gradients shall be one-half (0.5) percent along the crown and curb.

- Maximum street gradients shall be fifteen (15) percent for local streets and neighborhood routes, and ten (10) percent for all other streets. Grades in excess of fifteen (15) percent must be approved by the City Engineer or designee on an individual basis.

- Local streets intersecting with a neighborhood route or greater functional classification street or streets intended to be posted with a stop sign shall provide a landing averaging five (5) percent or less. Landings are that portion of the street within twenty (20) feet of the projected curb line of the intersecting street at full improvement.

- Grade changes of more than one (1) percent shall be accomplished with vertical curves.

- At street intersections, the crown of the major (higher classification) street shall continue through the intersection. The roadway section of the minor street will flatten to match the longitudinal grade of the major street at the projected curb line.

- Street grades, intersections, and super elevation transitions shall be designed to not allow concentrations of storm water to flow across the travel lanes.

- Off-set crowns shall be allowed only with the specific prior approval of the City Engineer or designee and must conform to the Standard Drawing for off-set crowns.

- Slope easements shall be dedicated or obtained for the purposes of grading outside of the right-of-way.

- Streets intersected by streets not constructed to full urban standards shall be designed to match both present and future (as far as practicable) vertical alignments of the intersecting street. The requirements of this manual shall be met for both present and future conditions.

When new streets are built adjacent to or crossing drainage ways, the following standards shall govern the vertical alignment:

FUNCTIONAL CLASSIFICATION	**VERTICAL STANDARD**
Freeways and Arterials	Travel lanes shall be at or above the 100 year flood elevation.
Collectors	Travel lanes shall be at or above the 50 year flood elevation but not lower than 6 inches below the 100 year flood elevation.
Neighborhood Routes and Local streets (residential)	Travel lanes shall be at or above the 25 year flood elevation but not lower than 6 inches below the 100 year flood elevation.
Local streets (non-residential)	Travel lanes shall be at or above the 25 year flood elevation but not lower than 6 inches below the 50 year flood elevation.

If alternate access is available for properties served by a particular local street, a design could be considered for approval by the City Engineer or designee that would set the travel lanes at or above the 10 year flood elevation but not lower than 6 inches below the 25 year flood event.

Vertical curves shall conform to the values found in Tables II·c and II·d.

TABLE II c – DESIGN CONTROLS FOR CREST VERTICAL CURVES BASED ON STOPPING SIGHT DISTANCE

DESIGN SPEED	MINIMUM k
25	20 – 20
30	30 – 30
35	40 – 50
40	60 – 80
45	80 – 120
50	110 – 160
55	150 - 220

SOURCE: REFERENCE 7.

$k = \frac{L}{A} = \frac{\text{feet}}{\text{Percent}}$

A = Algebraic Difference in grades, percent

L = Length of vertical curve, feet.

TABLE II d – DESIGN CONTROLS FOR SAG VERTICAL CURVES BASED ON STOPPING SIGHT DISTANCE

DESIGN SPEED	MINIMUM k
25	30 – 30
30	40 – 40
35	50 – 50
40	60 – 70
45	70 – 90
50	90 – 110
55	100 – 130

SOURCE: REFERENCE 9.

$k = \frac{L}{A} = \frac{\text{feet}}{\text{Percent}}$

A = Algebraic Difference in grades, percent

L = Length of vertical curve, feet.

AASHTO provides the designer of sag vertical curves the option of using shorter curves with the installation of street lighting. These "comfort" designs can also be slightly modified by providing a one (1) percent grade break at each end of the curve. The following table compares sag curve lengths using these criteria:

TABLE II e - DESIGN CONTROLS FOR LIGHTED SAG VERTICAL CURVES 25 Miles Per Hour

Algebraic Difference in Grades	Standard (k)	Comfort (k)	Comfort with Grade Breaks (k)
5.0%	30	13.4	8.0
7.5%	30	13.4	9.9
12.5%	30	13.4	11.3
17.5%	30	13.5	11.9

At the intersection of a local street with another local street or a neighborhood route, a minimum design speed of 15 MPH is allowed on the intersecting street. Minimum k factors for sag curves are as follows:

TABLE II f - DESIGN CONTROLS FOR LIGHTED SAG VERTICAL CURVES
15 Miles Per Hour

Algebraic Difference in Grades	Comfort (k)	Comfort with Grade Breaks (k)
5.0%	4.8	3.0
7.5%	4.8	3.6
12.5%	4.8	4.1
17.5%	4.9	4.3

SOURCE: REFERENCE 8.

210.5 INTERSECTION SIGHT DISTANCE POLICY

It is the policy of the City of Beaverton to have the applicant's Project Engineer evaluate safe intersection sight distance using the principles and methods recommended by AASHTO. This policy shall apply to the design of new streets and driveways, and to the placement of any object in the public right of way, including landscaping features. The following minimum standards shall apply:

INTERSECTION (and Driveway) SIGHT DISTANCE:

The following table is for intersection and driveway sight distances:

TABLE II g - CORNER SIGHT DISTANCE*

Traffic Speed (MPH)	Minimum Corner Sight Distance* (Feet)
20	210
25	260
30	310
35	360
40	415
45	465
50	515
55	565

*Distances in Table IIg are based on AASHTO Case IIIA.

Sight distance shall be determined for each street approach to an intersection. A driver on the approach street should be able to see each vehicle on the intersecting street from the time that the vehicle is the sight distance from the intersection until the time that the vehicle reaches the intersection. Poles, trees and similar obstructions will be allowed within the sight distance area only if it can be shown that such obstructions do not prevent the continuous view of the vehicle approaching on the intersecting street.

For purposes of this calculation, the driver's eye is assumed to be 15 feet from the near edge of the nearest lane of the intersecting street, and at a height range of 3.5 feet to 8 feet above the approach street pavement. The sight distance criteria should be met throughout the range of driver's eye heights. The top of the vehicle on the intersecting street is assumed to be 4.25 feet above the cross-street pavement.

The traffic speed used in the calculation shall be the highest of the following: (1) the design speed of the intersecting street; (2) the posted speed of the intersecting street; or (3) the measured 85th percentile speed of the intersecting street. Where the intersecting street is controlled by a stop sign or yield sign, a design speed of zero may be assumed. Where traffic signal control exists at an intersection or where a traffic signal is likely to be installed in the future, adequate sight distance shall be provided for potential right turns on red.

In some locations, maintenance of the required sight distance may require restrictions to potential development outside the public right of way. If so, the Project Engineer shall demonstrate that adequate restrictions are in place (and enforceable by the City) to assure that the required sight distance can be maintained in the future.

No modifications or exceptions to these standards shall be allowed unless approved by the City Engineer or designee.

210.6 ANGLES BETWEEN INTERSECTING STREETS

The following specifies the minimum requirements for intersections:

The interior angle at intersecting streets shall be kept as near to 90 degrees as possible and in no case shall it be less than 75 degrees. A tangent section shall be carried a minimum of 25 feet each side of intersecting right-of-way lines.

Curb radii at intersections shall be shown in Table II h for the various functional classifications. The right-of-way radii at intersections shall be sufficient to maintain at least the same right-of-way to curb spacing as the lower classified street.

Sidewalk access ramps shall be provided at all corners of all intersections, regardless of curb type, and shall conform to Standard Drawing 207.

TABLE II·h - TURNING RADII (FEET)
EDGE OF PAVEMENT/CURB - MINIMUMS

Street Classification	Arterial Street	Collector Street	Neighbor-hood Route	Transit Street	Commercial Industrial Street	Local Street
Arterial	55	40	30	40	40	25
Collector	40	40	30	40	40	25
Neighborhood Route	30	30	30	30	30	25
Transit Street	40	40	30	40	40	25
Commercial Industrial	40	40	30	40	40	25
Local	25	25	25	25	25	25

* If bike lane or on-street parking exists, above radii may be reduced by five (5) feet.
* The radii of the major street will be used for all intersection curb returns.

210.7 CUL-DE-SACS, EYEBROWS, TURNAROUNDS

The following specifies the minimum requirements for cul-de-sacs, eyebrows, and turnaround areas. Other turnaround geometrics may be used when conditions warrant and City Engineer or designee approves the design and application of its use.

- Cul-de-sacs, eyebrows, and turnaround areas shall be allowed only on local streets and commercial/industrial streets.

- Cul-de-sacs shall not be more than 200 feet in length, except for the modified infill design cul-de-sac which shall not be more than 150 feet in length, and shall conform to the requirements of the Development Code. The length of a cul-de-sac shall be measured along the center line of the cul-de-sac from the near side right-of-way of the nearest through traffic intersecting street to the farthest point of the cul-de-sac right-of-way. See Appendix B for cul-de-sac right-of-way and pavement requirements.

- The minimum curb radius for transitions into cul-de-sac bulbs shall be 25 feet, and the right-of-way radius shall be sufficient to maintain the same right-of-way to curb spacing as in the adjacent portion of the road.

- An eyebrow corner may be used on a local street where expected ADT will not exceed 500 vehicles per day or as otherwise approved by the City Engineer or designee. Minimum curb radius on the outside of an eyebrow corner is 36 feet;

minimum right-of-way radius is 45 feet. Eyebrow geometry shall be evaluated on the basis of turning requirements for Fire Department vehicles. The minimum curb radius is the straight line distance measured from the point of intersection of the tangents (of the projected centerline) to the face of the curb (36 feet required), or to the edge of right-of-way (45 feet required).

210.8 DRIVEWAY APPROACHES

The City Traffic Engineer has the authority to limit access and access locations. Access to streets and highways under Washington County or State of Oregon jurisdiction must be formally approved by those entities at the applicant's initiative and expense.

The following specifies the minimum requirements for driveways:

•Driveways shall not be permitted on streets with existing or proposed non-access reserve strips.

•The spacing requirements shall conform to the requirements of the City of Beaverton Development Code.

•Concentrated surface runoff shall not be allowed to flow over commercial driveways or sidewalks into the street.

•Driveways shall meet the minimum intersection sight distance requirements.

210.9 CURBS AND GRADING

When new curbing is being placed, a stamp or tag shall be placed to mark where each water and sanitary sewer service crosses the curb line. The method of marking the curb shall be approved by the City Engineer or designee and noted on the approved construction plans. If an imprinting stamp is used, the impression left for a water service shall be the letter "W"; for a sanitary service, it shall be the letter "S". These impressions shall be 2 inches high, placed on the top of the curb.

The following specifies the requirements for curbs and cross-slope grading for streets:

- All streets shall include curbs on both sides except in the situations of interim width improvements. Interim designs shall have shoulders and ditches.

- Interim width streets shall have 6-foot wide shoulders adjacent to the street at a 2-1/2 percent cross-slope and roadside ditches each side of the shoulders with a

maximum side-slope of 2 horizontal to 1 vertical. The 6-foot shoulder area may consist of a section of pavement and/or a section of crushed rock. The pavement section shall be a minimum of 2 feet wide and a maximum of 6 feet wide.

- Cross-slope of the street section shall be no less than 2.5 percent and no greater than 5 percent. Whenever possible, the crown of the street shall be the same elevation as the top of the curbs.

Grading outside the improved areas shall be as follows:

- Collectors or higher functional classifications shall have a maximum 2 percent upward grading to the right-of-way line, and no steeper than 1-1/2 to 1 up, or 2 to 1 down, outside the right-of-way.

- Local Street and Commercial/Industrial functional classifications shall have a maximum 2 percent upward grading to the right-of-way line, a 5 to 1 upward or downward grading within the public utility easement, and no steeper than 1-1/2 to 1 up, or 2 to 1 down outside the public utility easement.

- Retaining walls shall be used if slopes are greater than the 1-1/2 to 1 requirement in the paragraphs above or where slope stability is a problem. If slopes are to be maintained (mowed) by the City, a maximum of 3 to 1 slope will be required. Retaining walls shall be constructed to a height where the slope is no more than 1-1/2 to 1.

210.10 SIDEWALKS

The following specifies the requirements for sidewalks.

- Sidewalks shall be separated from the curb as indicated in the street standards in the Development Code and Appendix B, except, where physical or topographic conditions make it impracticable to separate the sidewalk from the curb, the City Engineer or designee may approve a design modification to allow the sidewalk to be adjacent to the curb subject to the requirements Development Code regarding Street Design Modifications.

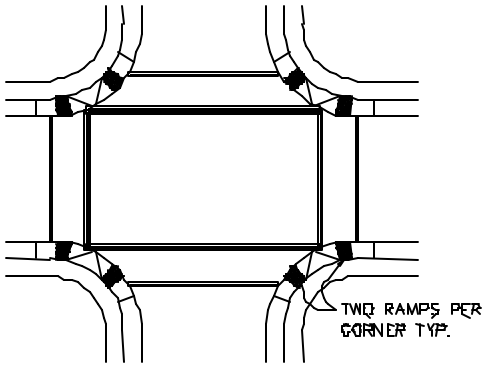
- Where clustered mailboxes or other objects larger than single mailboxes are within a sidewalk, the walk shall be widened to provide clearance equal to the required sidewalk width.

- In no case shall the sidewalk clear space be smaller than 42 inches.

- In instances where it is required to install sidewalks and a permanent sidewalk cannot be constructed, a temporary sidewalk may be constructed. The temporary sidewalk may consist of an asphaltic concrete or Portland cement concrete to a width, location, and structure approved by the City Engineer or designee.

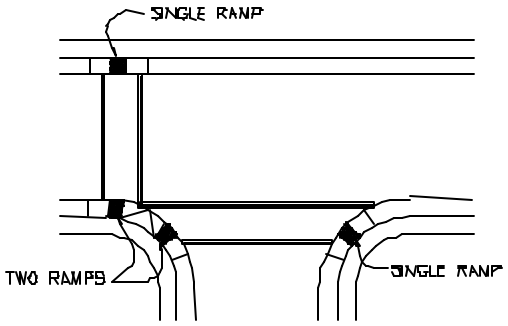
The following are the minimum requirements for location and construction of sidewalk ramps:

1. Sidewalk ramps shall be located and constructed in accordance with the rules and regulations of Title III of the Americans with Disabilities Act of 1990.
2. Crosswalks shall be marked (striped) only at crossings that are protected by a traffic signal, or stop sign, or at other locations recommended by the traffic commission and approved by the city council.
3. Ramps located within marked (striped) crossings shall be wholly within the crossing, excluding the flared wings. See figure A and B.
4. At unmarked crossings, ramps may be single (one ramp per street corner) diagonal ramps. See Figures C and D.
5. At Tee intersections, the “cross-bar” of the tee must have at least one crossing equipped with ramps, regardless of whether the crossings are marked or not. Thus, all Tee intersections shall have at least two single ramps and a third ramp that may be double or single, depending on whether the crossings are marked (striped). See Figures B and D.
6. Location of ramps and the minimum number of ramps per intersection shall be shown on the construction plans in accordance with these specifications and the diagrams that follow.



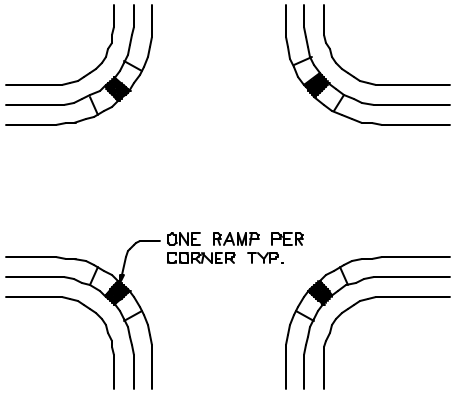
MARKED (STRIPED)
FOUR WAY INTERSECTION

FIGURE A



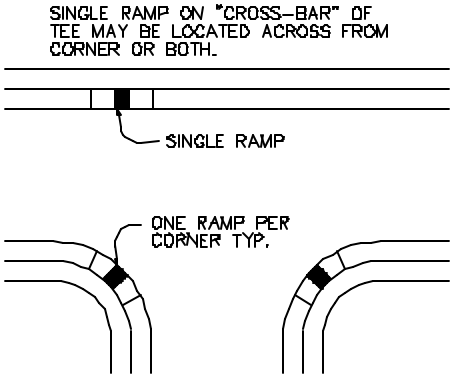
MARKED (STRIPED)
"T" INTERSECTION

FIGURE B



UNMARKED
FOUR WAY INTERSECTION

FIGURE C



UNMARKED
"T" INTERSECTION

FIGURE D

RAMPS SHOWN ARE THE MINIMUM NUMBER OF RAMPS REQUIRED. WHERE SINGLE RAMPS ARE SHOWN, DOUBLE RAMPS MAY BE SUBSTITUTED AT THE DISCRETION OF THE DESIGNER.

Also, pursuant to the U. S. Justice Department's two-year long suspension of the ADA guidelines for public sidewalk ramps, the requirement for "brick red" coloring of sidewalk ramps is likewise being suspended by the City, and Drawings No. 208 and 209 are revised accordingly.

210.11 RAISED MEDIANS

Where raised medians are allowed, the following criteria must be met:

- The raised median shall be set back at least 2 feet from the median lane on both sides.

- Street lighting shall be sufficient to provide illumination of the raised median.

- Objects, such as trees, shrubs, signs, and light poles shall not physically or visually interfere with vehicle or pedestrian traffic in the travel way.

- The style and design of the raised median shall be site specific. The raised median shall be safe for the design speed, and shall be subject to City approval.

210.12 SUBSURFACE DRAINAGE

Subsurface street drainage must be considered in the design of each street. Subsurface drains shall be designed and constructed per the recommendations of the soils report. In the event that no subsurface drainage is required on the soils report, a transverse perforated drain pipe shall be installed below the subbase rock at the low point of each sag vertical curve. The subsurface drains are for the purpose of collecting and conveying subsurface water only, not surface runoff. They are not to be considered part of the storm drainage system for storm drain pipe sizing purposes.

Subsurface drains shall connect and drain into the storm drainage system at catch basins, curb inlets, gutter inlets, manholes, or road side ditches. Alternative subsurface drainage measures may be used if approved by the City Engineer.

210.13 GUARDRAILS

The following specifies the minimum requirements for the location and type of guardrails:

- The decision of whether to install a guardrail or not shall be based on information found in AASHTO publication, GUIDE FOR SELECTING, LOCATING, AND DESIGNING TRAFFIC BARRIERS.
  SOURCE: REFERENCE 9.

- Guardrails shall be designed and constructed per ODOT's Standard Drawings for Design and Construction.
  SOURCE: REFERENCE 9.

210.14 TRANSITIONS

A. Street width transitions from a narrower width to a wider width shall be designed with a 3 to 1 taper. Delineators, as approved by the City, shall be installed to define the configuration.

B. For street width transitions from a wider width to a narrower width, the length of transition taper shall be determined as follows:

$L = S \times W$ (for S = 45 MPH or more)

$L = \frac{W \times (S)^2}{60}$ (for S = less than 45)

Where L = minimum length of taper (feet)

S = Design speed (MPH)

W = EP to EP offset width

Delineators, as approved by the City Engineer, may be installed to define the configuration. Maximum spacing of delineators shall be the numerical value of the design speed, in feet (i.e. 35- foot spacing for 35 MPH).

In situations where a tapered transition cannot be provided, a barricade shall be installed at the end of the wider section of the street and a taper shall be appointed and delineated as approved by the City Engineer. The barricade shall conform to the Standard Drawing. If the wider section does not provide an additional travel lane, only a barricade is required without the transition.

210.15 SUPER ELEVATION CROSS-SECTIONS

A. Off-set crown cross-sections are not acceptable as super elevation sections.

B. Super elevation sections shall be designed using AASHTO guidelines.

C. Super elevation transitions shall be designed to not allow concentrations of storm water to flow over the travel lanes.

210.16 STUB STREETS

Stub streets that are to allow for future extensions shall be barricaded and signed as per the Standard Drawings.

210.17 PRIVATE STREETS, PARKING LOTS, AND COMMON DRIVEWAYS

Streets, parking lots, and driveways on private property shall meet the requirements of the Development Code. The Engineer shall provide a pavement section design which provides a minimum loading capacity of 12,500 pounds per tire (considered to be one half (0.5) square feet). This design must meet or exceed the following minimum standards:

> Areas used for required parking or maneuvering of vehicles shall have a durable, hard surface. In all residential areas, a minimum of 2-1/2 inches asphalt over 4 inches of aggregate base will be provided or 4 inches of portland cement concrete over 2 inches of aggregate base. In commercial and industrial areas, either 3 inches of asphalt over 4 inches of aggregate base or 5 inches of portland cement concrete over 2 inches of aggregate base is required. The parking surface shall be placed on a well compacted subgrade. All required parking spaces shall be striped.

The elevation for short term parking will be no lower than one (1) foot below the 10 year flood plain. The elevation for long term parking will be no lower than the 100 year flood plain. Long term parking is defined as an unoccupied vehicle being left in one location for a period of greater than 12 hours.

Private streets serving residential areas shall be designed with travel lanes at or above the 25 year flood elevation but not lower than 6 inches below the 100 year flood elevation.

For driveways serving two or three single family homes, a minimum twenty (20) foot wide improvement in a twenty-five (25) foot aisle will be required if fire vehicle access is within 150 feet of all portions of building exteriors (as determined by the Fire Marshal). The twenty foot wide improvement is only necessary up to the point where access is shared by more than one home.

For driveways (or private streets) serving more than three single family homes, or where a fire vehicle turnaround is mandated due to the length of the driveway, a minimum twenty-four (24) foot wide improvement in a thirty (30) foot aisle will be required. (See City Standard Drawing 105).

The maximum slope for private streets and driveways serving two or more single family homes shall be 15.0 percent, with intersection areas no steeper than 5.0 percent.

210.18 UTILITIES

Utilities shall be located outside of the paved area of street if at all possible to avoid future street cuts. On all phased (interim) street improvements, the necessary utilities shall be stubbed across the interim improvement to insure that cuts are not necessary when the road is expanded to its full width.

Except for sanitary sewer, storm sewer, and water, underground utilities intended to provide direct service to adjacent properties with future connections shall not be located in the full-width paved section of a street to be constructed. If all service connections are existing and extend beyond the full-width section of a partially improved (or interim) street, underground utilities can be located in the future paved section of the street, if approved by the City Engineer.

Underground utilities being constructed along existing paved streets shall not be located under the existing pavement unless approved by the City Engineer. Underground utilities that must cross an existing paved street shall not be installed by any method which cuts the pavement or undermines the aggregate base of the street unless approved by the City Engineer.

Underground utilities shall be buried a minimum depth of thirty (30) inches as measured from finished grade to top of utility.

When new curbing is being placed, a stamp or tag shall be placed to mark where each water and sanitary sewer service crosses the curb line. The method of marking the curb shall be approved by the City Engineer and noted on the approved construction plans. If an imprinting stamp is used, the impression left for a water service shall be the letter "W"; for a sanitary sewer service, it shall be the letter "S". These impressions shall be two (2) inches high, placed on the top of the curb.

Ordinance 2050 requires all utilities to be placed underground (including existing overhead) within the project and along all existing street frontages. These undergrounding plans shall be reflected on the landscaping and street light plan sheet of the site development submittal. The following items shall be the minimum requirements for submittal (the City Engineer may request additional information): Conduit location or wire location for direct bury, buried structures, poles, and above ground structures (shown to scale and at exact locations as proposed by the utility companies). The City Engineer has determined that placing high voltage lines (57 kV

or greater) underground is not practical and is therefore not required pursuant to Ordinance 2050, Section 138.1.H; all other lines will be placed underground per the requirements of Ordinance 2050.

210.19 TRENCHING AND STREET CUTS

The City will not allow, without prior approval from the City Engineer and the Operations Director, any street cuts on newly paved or resurfaced streets (paved within the previous 12 months). The following is a list of exceptions. These exceptions do not require the City Engineer's approval. (However the appropriate documents must be submitted with the application for any street cut permit.):

A. A letter from an arborist indicating that boring would pose greater risk to a significant or protected tree than a conventional open street cut, or

B. A letter from the engineer of record and accompanying design indicating that the only possible vertical location of the line would be within the structural section (required aggregate base) of the street, or

C. The street cut will also include a minimum of a 2 inch deep grind and new asphaltic concrete for a distance equal to the street width from both sides of the trench or as determined necessary by an engineer specializing in pavement design to ensure no settling or loss in pavement life would be expected (whichever distance is greater), or

D. If the streets are surfaced with portland cement concrete, street cuts would be allowed. However, all concrete panels damaged by the street cut work must be removed and replaced with new portland cement concrete in their entirety (no partial panels).

Additional exceptions may be applied for by making a formal request along with appropriate documentation to the City Engineer.

All approved street cuts in streets of a higher functional classification than local residential shall be backfilled with Controlled Density Fill (CDF) meeting the material requirements of the supplier. However, the City Engineer may require CDF on residential local streets if conditions warrant.

The use of CDF as trench backfill is an approved method of backfill which the engineer may require or allow in lieu of aggregate or native materials as specified elsewhere in this document. CDF shall not be used for lengths greater than 100 feet. Should the required trench exceed 100 feet, then the City will determine where CDF will be

required on a case by case manor. When CDF is used, at a minimum, the pipe bedding shall be 3/4 inch minus aggregate; in addition, the top 12 inches of the trench backfill (below the pavement) shall also be 3/4 inch minus aggregate to allow subgrade drainage. In no circumstances shall CDF exceed 100 psi in 28 days (with a design strength not exceeding 150 psi in 90 days) for the pipe zone (public water, sewer, and storm) and for the remaining trench depth shall not exceed 200 psi in 28 days (with a design strength not exceeding 250 psi in 90 days).

The Engineer of record (or designee) shall be on site while the CDF is being placed in order to ensure that the proper mix is supplied and to ensure that the above minimum drainage requirements are met and, if subsurface drainage is excessive, to instruct the contractor to increase the depth of the 3/4 inch minus aggregate to ensure adequate subgrade drainage, especially in conditions where cross drainage occurs (sag vertical curves for example).

CDF shall be field tested by an independent laboratory per ASTM PS 28, 29, 30, and D 4832 standards (the field technician shall be ACI Certified or equivalent). The Engineer of Record and the independent laboratory shall record: the name of the supplier (the engineer of record shall include with their daily report a copy of all batch tickets), the temperature of the air, ground, and mix (at time of placement), the weather conditions, ground water conditions, other utilities encountered, and any other information which may affect the material. At a minimum 4 cylinders shall be taken each day, and different mix used. These cylinders shall be broken 1 at 7 days, 1 at 28 days, and 1 at 90 days with 1 reserve cylinder. All test reports shall be sent to the City Inspector, the Engineer of Record, and the supplier.

Prior to paving, the CDF shall be tested per ASTM PS 31 by the independent laboratory.

Street cuts must have the final pavement repair (matching existing material type) completed within 30 days from the date the pavement is cut unless an extension is approved by the City Engineer. The use of “cold patch” and steel plates will be allowed for up to the first 30 days after the pavement is cut, provided a daily inspection by the applicant is made and any necessary repairs are made on a timely basis. If the temporary patch is not monitored and maintained, the City Engineer may shorten the 30 day time limit.

End of Chapter